UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

RANGE RESEARCH

at

TUCSON RESEARCH CENTER

(Project Analysis)

M—5128

U. S. GOVERNMENT PRINTING OFFICE

8—7417

RANGE MANAGEMENT RESEARCH

at

TUCSON RESEARCH CENTER

Rocky Mountain Forest and Range Experiment Station

(A Project Analysis and Working Plan)

by

S. Clark Martin

Prepared:	Approved:	Date:
May 1, 1957	S. Clark Martin Research Center Leader	5/24/57
	Division Chief	
	Director	

TABLE OF CONTENTS

February 1957

RANGE RESEARCH AT THE TUCSON RESEARCH CENTER

by

S. Clark Martin, Range Conservationist[1/]

1/Acknowledgment is made to earlier research reports and analyses by M. J. Culley, K. W. Parker, C. K. Pearse, G. E. Glendening, and H. G. Reynolds and other authors from which most of the material in this report was obtained.

INTRODUCTION

The main purposes of this analysis are to describe and assign priority to the major range problems of the semidesert grassland type and to outline a program of range research to solve these problems. A third objective is to outline an overall program of grazing-management research for the Santa Rita Experimental Range which is characteristic of a large area of the semidesert range type. The program must include both basic and applied research and must fit in with the programs of other research agencies to provide a coordinated attack and to minimize duplication of effort. The ultimate aim of the research program, including that on the Santa Rita, is to improve and maintain the productivity of the range.

Our final research goal is to provide the knowledge for "ideal" range management, that is, management that will yield maximum profit consistent with conservation principles in the long run. However, in achieving this goal we are aware that it is not the researcher but the rancher who must put research results into practice. And, the rancher's desire to achieve "ideal" range management is always tempered by economic necessity. Consequently, our research program must seek solutions that

will not only meet the needs of the plants and the soil but also return a profit as well. Certainly, the road to better rangeland use throughout the semidesert range area will be wider, smoother, and faster if it is paved with rancher profits.

LOCATION AND DESCRIPTION

The semidesert-grassland-shrub type covers about 60 million acres mainly in western Texas and in the southern parts of New Mexico and Arizona.

Rainfall ranges from 8 to 20 inches per year with an average of about 12 inches. However, in most of the area rainfall is concentrated in the growing season. This permits development of grassland on some soil types, even with an average yearly rainfall as low as 8 or 9 inches. Growth response to summer rainfall is rapid. Most of the perennial grass herbage is produced during the summer rainy season.

The relatively low rainfall of the semidesert region is sufficient to support only a sparse vegetation. Year-to-year fluctuations in rainfall are relatively great and 2 to 3 or more years out of 10 are drought years. When two or more drought years come together, any gains in grass density or range condition that may have been made in good years are often wiped out.

VEGETATION

The semidesert range area includes the following vegetational communities: (1) the black grama (Bouteloua eriopoda) grassland of New Mexico and west Texas, (2) the flood plains or flats of tobosa (Hilaria mutica) or alkali sacaton (Sporobolus airoides) that occur along water courses throughout the region, (3) the mixed grama (Bouteloua spp.)

grasslands of Arizona and west Texas, (4) the mesquite (Prosopis spp.) grasslands of Arizona and west Texas, (5) the mesquite sandhills of eastern Arizona, New Mexico, and west Texas, and (6) the widespread creosotebush (Larrea tridentata) areas.

The distribution, floristic characteristics, and successional stages of these vegetational communities have been described by Shantz and Zon (40), Shreve (41, 42), Clements (11), Campbell (3, 4) and Talbot (44). The grassland types, particularly the grama communities, are most valuable for grazing. The mesquite sandhills and creosotebush types are characteristically low in forage values. The grass forage, at least in some areas, becomes deficient for animal health in protein and phosphorus during the dormant season. These deficiencies have been determined and described by Watkins (47), Lantow (26), Knox and Watkins (25), and Stanley and Hodgson (43).

TOPOGRAPHY AND SOILS

Most of the semidesert range area varies in elevation from 3,000 to 5,000 feet but is interrupted here and there by mountain ranges which may rise abruptly to elevations of 9,000 feet or more. Soils are typically those of the semidesert. The mesa and upland soils of the black grama community are light, shallow (usually 12 inches or less in depth), and are frequently underlain by caliche. The mixed grama and mesquite-grassland types occur on a wide variety of soils. The creosotebush type usually is associated with calcareous soils and is often underlain by caliche. It is also found on valley fills and other deep soils of alluvial origin.

RANGE PROBLEMS ON SEMIDESERT RANGE

Early cattle operations were first centered around natural water with the result that the range near water was overgrazed while vast areas remote from water were grazed very lightly or not at all. Thus, one of the first range problems was that of getting better livestock distribution. Development of wells and ponds on once-dry range now enables the stockman to make good use of most of the range. However, these same devices can be, and sometimes have been, used to keep too many cattle on the range for too long.

Some of the pioneer stockman's most critical range problems were the result of either "too little grass" or "too many cattle" during "hard" winters or periods of drought. Because of large year-to-year fluctuations in forage production, this old problem persists in varying degree today. But even in good years, many of our semidesert ranges are not so productive now as they once were. Such ranges actually are producing "too little grass." In some cases "too many cattle" at some time or another have been partly responsible for present low forage production. In others, the invasion of grasslands by mesquite and other woody plants appears to be the cause of reduced forage production. Glendening and Paulsen (23) found that cattle had a part in the spread of these woody plants. Failure to rest the range by some sort of seasonal grazing program may also be responsible for some of the decline on semidesert ranges that are grazed yearlong. Regardless of the causes for present unsatisfactory range conditions, many of our semidesert ranges have more brush, more erosion, and less forage than they should have.

On such ranges, the foremost problem is to restore and maintain maximum range productivity. However, this one big problem is made up of several groups of more specific, but complexly interrelated problems, whose solutions must be obtained and integrated into systems of range and ranch management if full production is to be restored and maintained. These more specialized range problems and their solutions are often grouped under such headings as grazing management, plant control, range reseeding, range-animal husbandry, range economics, range soils, range watersheds, and insects and diseases of range plants. Unfortunately, the major problems on semidesert range do not fit neatly into these functional groupings. For when we consider the overall problem of range deterioration we find that it may be due in part to improper grazing, partly to drought, partly to invasions of nonforage plants, and partly to insect and disease activities on forage plants. Or, if we consider plant control a primary problem, we find that plant invasions are caused partly by the actions of grazing animals and that drought and soil erosion also may be contributing factors.

PROBLEMS OF FIRST PRIORITY

In considering all of the many problems that confront the cattle rancher on semidesert range, three stand out. Each of these problems is large enough to justify a sizable research program including both basic and applied research. Each is sufficiently distinct to warrant being listed separately for the sake of emphasis. But, all three are so complexly interrelated that adequate discussion of one must necessarily involve the other two. These three problems, which will be discussed

separately in some detail are: (a) Learning to cope with drought and its impact on vegetation, livestock, and grazing use, (b) controlling unwanted woody plants such as mesquite, cactus, and/or other shrubs, and recovering lost grazing capacity, and (c) maintaining the productivity of yearlong range by preventing declines in range condition and grazing capacity apart from those due to drought or shrub invasion.

Learning to Cope With Drought

The climate of the semidesert range area is normally dry and rainfall is erratic. Early workers pointed out that drought years must be expected and planned for by leaving a forage reserve in average-to-good years to carry the herd through the inevitable drought years. Only recently have we realized that drought may continue year after year and so have profound cumulative effects on vegetation (38).

Thus, because of drought, the semidesert grassland-shrub vegetation lacks stability, and this poses serious problems for the rancher. Forage production varies so greatly from year-to-year that average grazing capacity has little meaning. Since range forage is perishable, the desirability of attempting to save the excess forage from a wet year to carry one through the next dry year may not be practical. On the other hand, since drought cannot be predicted, a completely flexible system of stocking may not be practical either.

To confuse the picture further, the effects of varying degrees of grazing use on drought mortality of perennial grasses is not well understood. General observations on perennial grasses in and around exclosures on the Santa Rita Experimental Range in southern Arizona indicate that drought mortality is often as great or greater inside than outside. The validity of these observations has not been adequately tested by research.

To make such a test it appears that research on the drought problem must include detailed studies of the important forage plants and how they react to varying conditions of drought and grazing.

Since methods are not available for predicting drought occurrence or severity a year or more in advance and since rain-making efforts have thus far been so unsuccessful as to hold little promise, drought remains as a major problem on semidesert range. Studies of how range plants react to drought should have high priority for research. In such studies the interactions between drought and grazing are especially important. Intimate knowledge of how important forage plants react to drought and grazing will provide the basis for practical solutions to the rancher's drought problems.

Controlling Unwanted Woody Plants

The serious nature of shrub invasion was pointed out by ecologists more than 50 years ago. Many, perhaps most, semidesert ranges have been invaded to some degree by mesquite and/or other low value shrubs. Research has shown that the production of perennial grasses decreases as the density of the shrub stand increases (36). Once started, the gradual change from grass to shrubs seems to be self-perpetuating. On the Santa Rita Experimental Range and many similar areas the ultimate result appears to be dominance of the site by a mesquite canopy and an understory of half-shrubs with grass production limited mainly to annuals and short-lived perennials in better than average rainfall years (37). To reverse the direction of change appears to require removal of the woody plants together with good grazing management.

Grazing management in relation to mesquite or other invasions may be divided into distinct phases such as: (1) managing cleared ranges to increase forage production and to retard reinvasion, (2) manipulation of grazing to increase the effectiveness of burning, spraying, chaining, and other direct methods of shrub control, and (3) managing infested ranges for maximum beef production consistent with the ultimate aim of restoring such ranges to full productivity.

Managing cleared ranges.--There are several known ways in which grazing by cattle affects the rate of grass recovery and the rate of reinvasion on ranges recently cleared of mesquite. With some modification, the same principles apply to ranges cleared of other woody shrubs. There can be no doubt but that improper grazing is detrimental to perennial grasses and consequently detrimental to range recovery. On the brush-control side, it has also been established that it is more difficult for a mesquite seedling to become established in a stand of grass than on a bare area (23). So, grazing that destroys grass encourages brush too. However, there are many gaps in our information as to what constitutes proper grazing on semidesert range. Rates of stocking, seasons of use, periods of rest, and similar factors all need further study.

The role of cattle in dispersing seed of mesquite has rather clear-cut implications relative to the spread of mesquite. At certain times during the year, cattle droppings in a mesquite area contain viable mesquite seeds, and cattle will pass viable mesquite seeds for at least a week after ingestion (21). For this reason cattle are thought to be a major factor in the spread of mesquite. It is apparent that cattle that have been feeding on mesquite beans should not be introduced to a

mesquite-free area until they have been kept away from mesquite long enough to clear their digestive tracts of viable seed. Another implication is that complete eradication of mesquite should be the control objective in each pasture where it is undertaken. Otherwise, a few heavy bearing mesquite trees can soon infest the pasture with a new crop of seedlings. Partial control of seed distribution by cattle may be possible by grazing the range at times of the year when cattle are not feeding on mesquite beans. However, the degree of control obtained in this manner may be variable because cattle not only pick beans off the tree but will gather them up off the ground long after they have fallen.

Managing grazing to aid in mesquite control.--The use of grazing management as an aid to mesquite control or control of other shrubby species appears to be primarily a job of so grazing the range that forage plants will compete more vigorously with mesquite seedlings for moisture and soil nutrients. More information is needed on the manipulation of grazing use before and after mesquite control. Where burning is the control method, there is the added function of allowing enough fuel to accumulate to permit an effective burn. Otherwise, grazing management problems on ranges being cleared are essentially the same as those on a cleared range.

Managing low-value infested ranges.--Semidesert ranges that are already covered with brush have their own management problems. Productivity of many such areas is so low and the cost of clearing by present methods so high that clearing is impractical. Consequently, these areas will probably remain in brush for the foreseeable future. The lower pastures of the Santa Rita are typical of low-value semidesert range. Some areas once supported fair stands of perennial grasses which have all

but passed out of the picture. Should such ranges be stocked in accordance with yields of perennial grasses? Such a policy, if strictly adhered to, sometimes results in stocking rates that appear ridiculously low. The question then arises as to whether other kinds of forage such as annual grasses and browse should be included in the total amount of forage on which stocking is based. Another consideration is whether temporary heavy grazing of these ranges does serious damage. It is conceivable, for example, that the browse on brush ranges could be used to carry the breeding herd through a drought, thereby providing a rest period for more valuable brush-free grass range at a higher elevation where rainfall is greater. It is possible, also, that some of these drier ranges are more valuable in brush than in grass. Perhaps the year-to-year fluctuation in herbage yields and livestock condition would be greater if the brush were removed and grasses were the only source of forage. Answers to these and many other questions must come from additional research.

The usual approach on a noxious plant problem is to determine, first, its seriousness in terms of acreage involved, detriment to forage production, rate of spread, and benefits to be derived from eradication or control. If the problem is serious enough to warrant further study, research on control methods may be initiated. Control methods to be tested may include chemical, mechanical, and ecological techniques--the use of fire, grazing management, or anything else that promises to work. Mesquite has already been established as an undesirable range plant and is now being subjected to many control techniques in an effort to find an efficient, practical method that will enable ranchers to rid their lands of this range pest. This work must be continued because control methods developed to date

are either too costly or too unreliable for widespread use by stockmen. In the meantime, evaluation and methods-of-control research are progressing on cactus, burroweed, and a number of other species.

Noxious plant control certainly deserves high priority in any research program on semidesert range. The search for better chemical and mechanical methods of control by the Agricultural Research Service and by state and private agencies must be encouraged. The Forest Service must explore the possibilities of control and eradication through the use of fire, improved grazing management, and a better knowledge of pertinent ecological factors.

Maintaining Productivity of Yearlong Range

It is evident from previous discussion that the reduced carrying capacities of southwestern semidesert ranges can be attributed in part to drought, shrub invasion, or both. The apparent objective of grazing management research as related to drought is to minimize the harmful effect of drought on the range. The apparent objectives of grazing management research in relation to shrub invasion should be not only to reduce the harmful effects of shrub invasions but also to retard, prevent, or repel the invasions themselves. A third broad objective of grazing management research is to develop grazing systems that will reverse the downward trends in grazing capacity or range condition that are directly attributable to faulty grazing management and not primarily to drought or shrub invasion or some combination of the two.

Yearlong grazing is traditional on semidesert ranges. However, examples of ranges being maintained in a satisfactory condition under such grazing are rare. Numerous observations lead to the conclusion that yearlong

grazing of semidesert ranges at any practical rate will ultimately lead to deterioration of the better forage species, at least on easily accessible sites. There are indications that rest at any time is advantageous, but it is suspected that periods of summer growth and spring drought may be most critical.

Grazing management research should be aimed at developing grazing systems that over a period of years will provide the maximum profit consistent with primary objectives of maintaining and improving the range. In the development of such a system, the needs of the plants, the needs of the livestock, and the needs of the livestock-owner must all be considered. The needs of the plants to be able to grow and reproduce are listed first because without forage plants there could be no range livestock, and without livestock there could be no rancher. For the plant, good grazing management means grazing in such a way that the species can maintain high vigor and maintain or increase in abundance and production. On the range, it means grazing at the right intensity and season to maintain a desirable species composition and near optimum forage density. Good grazing management for cattle puts more emphasis on using each forage species at the time when it is most nutritious and most palatable. The immediate needs of both plants and animals are not always satisfied by the same conditions. So, a good system of management may have to include frequent changes so that the needs of the plants and animals are alternately favored.

Grazing management, including grazing capacity, season of use, distribution, drought influence, and the effects of grazing on shrub invasion, is probably the research field of highest priority in the semidesert area.

Every effort should be made to accelerate and expand research in grazing management with emphasis on the relation of grazing to drought, to shrub invasion and control, and to maintaining or increasing forage yields.

PROBLEMS OF SECOND PRIORITY

In addition to the three major range problems just discussed are a number of others which in places may be just as urgent but which are rated lower in priority because they are not so universal, because their impact is less severe or not so well known, or because their solutions are dependent in part on the solutions to problems of higher priority. These include: (a) controlling gullying and head cutting, (b) revegetating depleted areas, (c) providing adequate year-round nutrition for range cattle, (d) making efficient use of precipitation, (e) interpreting research results in economic terms, and (f) evaluating the impact of range insects and diseases. These problems are not entirely distinct from each other and all are related to the three major problems listed previously.

Controlling Gullying and Head Cutting

Controlling erosion, especially gullying and head cutting, is a serious problem on semidesert ranges where the relatively sparse vegetation offers inadequate protection to the soil during torrential summer rainstorms. The trailing of cattle up and down the bottoms of the water courses opens up the vegetation at the most critical point. Even on some of our best managed ranges, cattle trails have started head cutting gullies along the natural water drainages. Practical methods of preventing initial gullying and of healing existing gullies are badly needed. Some

approaches to the problem which should be evaluated by research include: (a) the use of short drift fences across water courses to prevent the formation of cattle trails in critical areas, (b) grading down steep gully banks and head cuts and reseeding to aid in healing existing gullies, (c) the control of woody plants along water courses in order to provide a more adequate herbaceous cover, and (d) the use of seasonal grazing, salting, and other methods of grazing control to reduce the impact of grazing on the vegetation along water courses.

Revegetating Depleted Areas

Reseeding, if successful, can help the rancher in a number of ways. Depleted areas sometimes can be restored to productivity more rapidly than by waiting for nature to do the job. The green forage period can be lengthened by using species that green up earlier or stay green later. Species of varying palatability may be used to influence livestock distribution. Perhaps the greatest need on semidesert range where most of the native grasses are summer growers is for a cool-season species that can be easily established by reseeding. Such a species would be a great help in wintering livestock on the range. It would reduce the requirements for protein and mineral supplements and would bring the cattle through the winter in better condition.

Reseeding research probably is second in priority only to plant control as an improvement practice for semidesert range. Many areas where the sparsity of forage stand suggests that reseeding is needed are the same areas where plant control is also needed. In such areas, experience indicates that plant control is an essential prerequisite to successful reseedings.

Providing Adequate Year-round Nutrition for Range Cattle

The mild winters and long frost-free seasons of the Southwest have encouraged yearlong grazing. However, because of the aridity of the region, long summers and mild winters do not provide year-round green forage. Instead, the summer growing season is limited to the period of effective rains, which ranges from 2 to 12 weeks (18), and which averages only about 7 weeks on the Santa Rita Experimental Range. Contrary to popular opinion, research has demonstrated that semidesert range grasses quickly drop below minimum levels in phosphorus, protein, and carotene, when the plants dry up and lose their green color (43, 2, 47, 26). Additional research of this nature is needed to point the way toward more satisfactory and more economical ways to maintain an adequate year-round plane of nutrition for cattle on semidesert ranges.

Making Efficient Use of Precipitation

A good understanding of plant-soil relationships and of plant-soil-water relationships is fundamental to the management of semidesert range. Most of the semidesert range does not contribute water directly to a pond or to an irrigation reservoir but the surface soils of the entire region serve as a moisture reservoir for plant growth. The efficiency of the soil as a moisture reservoir depends largely on how well it is able to take up rain water and how well it is able to retain the water against evaporation. Both qualities are affected greatly by surface conditions. Any sort of cover, of vegetation or litter, will usually increase the rate of infiltration and retard evaporation, thereby providing more moisture for plant growth.

A pertinent phase of study in this field might be to determine the relative benefits of moisture conservation in terms of herbage production. The interaction between soil type and efficiency of rainfall, and the value of water spreading, pitting, and other devices for getting more benefit from the water that does fall are some of the plant-soil-water relationships that deserve further study.

It seems obvious that one of the essentials of good range management is to have enough herbage and litter on the ground to insure efficient use of the rainfall. However, who is prepared to say just how much of the current year's herbage should be left? And, should the amount left be established as so many pounds per acre or as a given percentage of the current year's production? Research is needed to answer these and many other related questions.

Interpreting Research Results in Economic Terms

Range economics studies that interpret range research in dollars and cents provide the final link between the range researcher and the rancher. Such studies must draw on information from grazing management, animal husbandry, and other phases of range research. Economic research results for semidesert range are badly needed but it is doubtful whether other lines of range research are far enough advanced to provide a sound basis for full scale economic studies. Economic studies, though high in overall importance, are considered relatively low in range research priority. However, all range studies should be conducted in such a way that economic interpretations are possible. To insure that this is done, the economist should be brought in on the planning of all types of ranch

research projects. In this way, all range research is economic research in that it will contribute something to the economist's store of essential facts.

Evaluating the Impact of Range Insects and Diseases

The various insects and diseases that affect range plants undoubtedly have important effects on a number of range problems. The most likely field of investigation for insect and disease research appears to be that of determining which insects and/or diseases have significant influences on the direction or rate of plant succession under various southwestern semidesert vegetation types and conditions. However, the role of insects and diseases in the ecology of semidesert ranges has received so little research attention that it would be presumptious to suggest that one line of research might be more rewarding than another. Probably the greatest need at present is for an evaluation of current knowledge to use as a starting point for further research.

RESEARCH IN PROGRESS

Range research on semidesert land is being conducted by the Forest Service, the Agricultural Research Service, the University of Arizona, the A & M College of New Mexico, and by a number of state and private institutions in Texas. Federal Experimental Ranges are the Jornada Experimental Range near Las Cruces, New Mexico, which is now maintained by the Agricultural Research Service, and the Santa Rita Experimental Range near Tucson, Arizona, which is maintained by the Rocky Mountain Forest and Range Experiment Station of the Forest Service. The Agricultural Research

Service has projects on mesquite control at Tucson, Arizona, and at Spur and College Station in Texas. A limited amount of range reseeding research is also being done by the Agricultural Research Service at several points within the region.

Up to this point we have been discussing problems common to most of the southwestern semidesert range area. We have pointed out the importance of drought, shrub invasion, and declining forage production as problems confronting the average stockman. We have also discussed the need for research on several other types of range problems. Subsequent discussion will deal more specifically with the Santa Rita Experimental Range, its representativeness of semidesert range in general, its suitability for conducting research on semidesert range problems, and a proposed program of grazing management research designed to help answer those problems.

THE SANTA RITA EXPERIMENTAL RANGE

LOCATION AND DESCRIPTION

The Santa Rita Experimental Range, located about 30 miles south of Tucson, Arizona, is typical of extensive southern Arizona rangelands at moderate elevations which support a plant cover characterized by a mixture of nutritious grasses and invading shrubs (fig.1). As such it provides an excellent opportunity to study the grazing problems of such semidesert grassland-shrub ranges. Previous analyses and publications have provided much background information on the characteristics of grassland-shrub ranges, and have summarized the history of research on the Santa Rita and presented major research accomplishments (20, 35). Accordingly, these aspects will be reviewed only briefly.

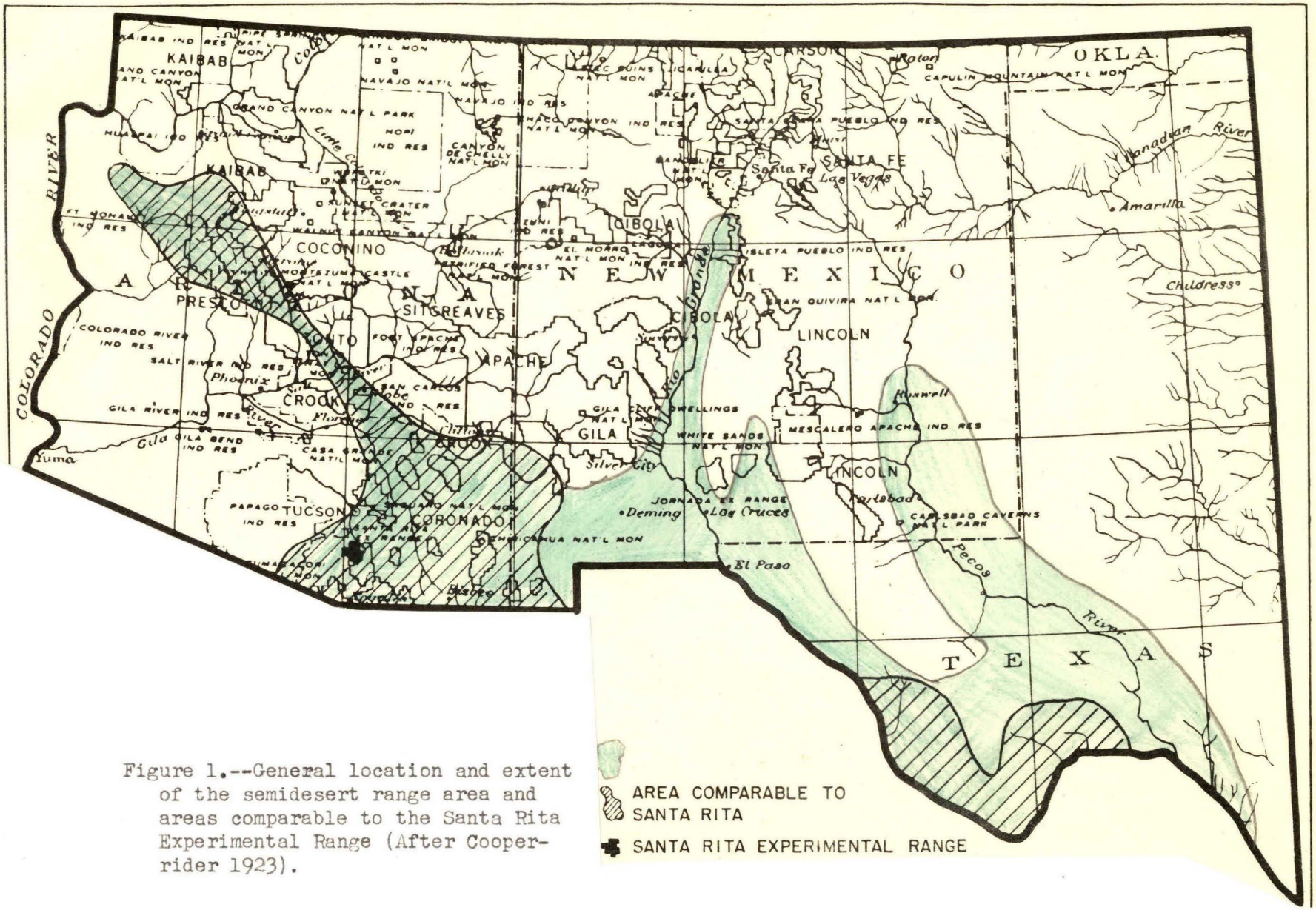


Figure 1.--General location and extent of the semidesert range area and areas comparable to the Santa Rita Experimental Range (After Cooperrider 1923).

Figure 1.--General location and extent of the semidesert range area and areas comparable to the Santa Rita Experimental Range (after Cooperrider 1923).

The climate of the Santa Rita Experimental Range is typically semiarid. Average annual precipitation varies from 12 to 18 inches, depending on elevation, with 50 to 60 percent occurring during the summer months. Evaporation is intense and much of the summer rainfall occurs as torrential storms so that much water is lost as surface runoff. Drought, severe enough to necessitate livestock reductions, occurs on an average of 3 to 4 years out of 10. Up to 9 consecutive years may be drought years. Temperatures are high in summer, and winters are warm enough to permit yearlong grazing.

The vegetation of the Santa Rita is predominantly a mixture of perennial grasses with varying amounts of shrub overstory. The gramas (Bouteloua spp.), three-awns (Aristida spp.), and dropseeds (Sporobolus spp.) are among the most widely represented grass genera. The shrubby overstory includes mesquite, cholla and pricklypear cactus, catclaw (Acacia greggii), whitethorn (A. constricta), and other species of Acacia and burroweed (Aplopappus tenuisectus). Most of these shrubs are of little forage value and have other undesirable characteristics such as high water requirements and a tendency to develop spiny thickets which reduce grass production and make livestock handling difficult.

PRESENT AND PAST USE

The Santa Rita, like most semidesert range, is grazed by cattle. Cattle operations are cow and calf outfits with calves being sold in the fall as weaners. Since marketing normally is done in the fall just after forage growth is completed it is possible to adjust sales somewhat in accordance with the immediate forage prospect. The rancher can cull heavily in poor years and can hold a few extra calves over in good years.

When the Santa Rita was established in 1903, it was recognized that the forage cover was seriously depleted. The area was fenced and domestic livestock were excluded to determine the time required for recovery. It was believed that this was achieved by 1912. The area was restocked with cattle in 1915 when the Forest Service was given responsibility for the studies. These were conducted under cooperative agreements with three local cattlemen who furnished the cattle but agreed to manage them in accordance with a plan designed to provide answers to urgent problems facing the industry.

Since grazing was commenced in 1915, with minor exceptions, no deviation from a plan of continuous yearlong grazing has been attempted. The exceptions are partial deferment of one pasture during the summer growing season, and deferment of bull pastures from March through November. Primary objectives have been those of determining (1) grazing capacity without loss of range productivity, and (2) the advantages of maintaining a good grade of cattle under fence. Secondary objectives have been concerned with animal losses, cost of handling, possibilities for range

improvement, number and distribution of watering places, advisability of holding heifers from breeding until 20 months of age, and the advantage of supplemental feeding to maintain good breeding condition. Grazing animals are furnished by three stockmen who are under cooperative agreement with the Secretary of Agriculture. The cooperators are Keith S. Brown, Henry Proctor, and Mrs. Feliz Ruelas.

The procedures followed in setting stocking rates and for following changes in range vegetation have been somewhat as follows: At the end of the growing season, usually in October, an estimate is made of forage production. This estimate is based partly upon judgment and partly upon herbage yield records from four or more forage panels per pasture. Using this estimate, past stocking records, the previous year's utilization records, and consideration with the cooperators, a management plan is prepared which stipulates the number of animals to be grazed in each pasture. Cooperarors are obligated to stay within this plan. All animal movements, calf brandings, death losses, supplemental feeding, salting, sales, and other pertinent information are entered in a monthly record book and submitted by each cooperator. These records are summarized in permanent record books.

Measurements of change in vegetation associated with time are limited to (1) permanent paced transect locations where utilization is measured annually, (2) grazed vs. protected enclosures which are measured periodically, and (3) permanent line transects which are located in pastures 8, 2, and 5. The original plan of charting vegetational changes on meter-square quadrats was abandoned on the Experimental Range about 1935.

PUBLISHED FINDINGS

One of the earliest records of research progress on the Experimental Range is that of a printed field day circular dated 1925 (45). At that time results indicated that (1) there were monetary advantages to raising cattle on fenced ranges; (2) considerable improvement in quality and conformation of range cattle could be achieved by selection and culling; (3) high calf crops were the result of (a) conservative stocking, (b) proper supervision, (c) maintaining at least a 1:25 bull:cow ratio, (d) culling of aged and sterile cows, (e) segregation of breeding from nonbreeding stock, and (f) a plentiful supply of water and salt; (4) low death losses were associated with conservative stocking, careful handling and adequate supervision; (5) depleted ranges can be brought back to productivity by conservative grazing; (6) climatic vagaries cause great changes in density and volume growth of forage plants; (7) seasonal use of forage is desirable, e.g., summer use of annuals; and (8) 10 to 15 percent of the average year's growth of important palatable grasses should remain at the end of the grazing year.

The second major contribution from the Experimental Range appeared about 12 years later at which time Culley (13) summarized cost and return data. Among the factors believed to increase herd earnings he listed; (1) stocking with at least a 15 percent herbage reserve, (2) maintaining a high calf crop by conservative stocking, use of active bulls, and careful culling, (3) a regular fall-winter sale of calves, (4) regulated breeding season, (5) use of selected registered bulls, and (6) reduction of animal losses to a minimum. A summary of clipping work during this same period showed that native perennial grasses should not be clipped too closely or frequently (12).

During the 1930's, with the availability of CCC manpower and funds, experimental work was expanded greatly on the Experimental Range. Two major lines of work, artificial reseeding and noxious plant control, were commenced and grazing management studies were expanded. Reseeding work included fundamental investigations of germination, effect of litter, and methods of transplanting. As a result of these studies, a guide was prepared for CCC personnel doing revegetation work on semidesert rangelands in the Southwest (10).

Initially, work on noxious plants was devoted entirely to burroweed. Humphrey (24) concluded that fewer burroweed seedlings became established where there was a good cover of grass; that torch-burning, acid-spraying, and grubbing as methods of control were not practical on low value rangelands. Broadcast burning was believed to have possibilities for eradicating burroweed where there was enough inflammable material to carry a fire. In subsequent work, Parker (30) recommended grubbing of light stands and spring treatment of heavy stands by either burning or application of chlorate. At about this time grazing habits of cattle were also investigated by Lister (27) and Culley (14). In another facet of investigation, the effect of rodents upon rangelands was determined (15).

During the war years and the rehabilitation period, three major developments were noteworthy. First, major effort on noxious plant control was shifted to mesquite and cactus. Second, much accumulated information was released in popular form. Third, a new technique was introduced, tested, and developed for measuring range vegetation.

The first work on mesquite was concerned largely with the use of arsenic. Early work was reported by Parker (31) and later summarized in a U. S. Department of Agriculture Leaflet (33). The diesel oil treatment

on single stems was evaluated by Martin (29). To date this method remains the most practical method for eliminating low densities of mesquite infestations. The entire problem of mesquite invasion and control has recently been summarized in a U.S. Department of Agriculture Circular (36). Thus far, the work on mass aerial application of herbicides to mesquite has not proved economically feasible.

Popular releases during the war years included a wide variety of subjects. An analysis of rainfall records showed that rather widespread range depletion and lack of growth is not due to lessened rainfall, and that too heavy stocking is the more responsible factor in range depletion (16). Another rainfall analysis cautioned that to be on the safe side 90 percent of the time no more than 50 to 60 percent of average rainfall should be expected (28). A more recent analysis has indicated the deleterious effects of successive years of below average rainfall upon forage production (38). Evaluation of summer rainfall suggests that 93 percent of the perennial grass growth occurs in a period of about 7 weeks starting about July 4(18).

Several papers described the practice and advantages of conservative grazing. Always having sufficient forage resulted in larger cows, heavier calves, higher calf crops, and lower death losses (17). Maintaining 50 to 60 percent of the annual herbage crop is as important as grazing a young, high quality breeding herd (34). Grazing capacity must also be based upon potential of the range for production (10). The advantages of conservative stocking were succinctly summarized in wartime leaflets (32, 47), as: heavy cow and calf weights and high calf crops, vigorous growing range-forage plants, and forage insurance during drought.

Among the factors found to be important for increasing calf crop were (19): (1) Maintaining a good supply of forage for top condition of

breeding animals, (2) fencing of ranges into units which will accommodate 50 to 100 animals, (3) maintaining young active bulls, (4) distributing bulls well over the range, (5) not breeding heifers before they reach 2 years of age, (6) keeping the bull-cow ratio between 1:12 and 1:20, and (7) observing a March through November breeding season.

Excessive death losses were found to be associated with (1) failure of stockmen to recognize the full import of livestock losses on their income, (2) insufficient feed or essential minerals, and (3) incompetent help and inadequate supervision.

Improvement in technique has stemmed largely from the development and testing of the line interception method (5), which is based upon measurement of the intercept of plants growing on randomly located lines of equal length. Sampling with this technique gives estimates of density, composition, ecological structure, and grazing use of vegetation. The line can be extended into a belt for measuring forage production (7). Outgrowths of analyses by this technique have been derivation of a short-cut method for measuring forage utilization (8), determination of the relative preferences of cattle for common perennial grasses (6), and determination of a percent ungrazed plant method of measuring grazing use (39). Another significant contribution based on the intercept method has been an analysis of the composition of perennial grasses under different intensities of grazing (9).

Two other investigations have an important bearing upon devising a new work plan for the Experimental Range. Measurement of the quantitative increase in woody plants led to the conclusion that (22): (1) mesquite, once established, will continue to increase in spite of grazing treatment, and the increase is accompanied by a loss of perennial grass, (2)

moderation in grazing may delay but will not halt the invasion of mesquite, and (3) artificial control of mesquite may be the only means for re-establishing a desirable grass cover.

The other investigation evaluates the place of artificial reseeding in the restoration of depleted desert grassland ranges (1). For the Experimental Range, adaptable species are mostly limited to Lehmann, Boer, and Wilman lovegrasses (Eragrostis spp.), and the uncertainty of rainfall reduces the likelihood of obtaining a stand every year even when proper methods for planting are observed.

RESEARCH OBJECTIVES

The earliest stated objectives for research on the Santa Rita were: (1) to demonstrate that rundown ranges will recover, (2) to find out how long it takes for ranges to recover, (3) to find out how to measure carrying capacity, and (4) to carry out reseeding studies. So, even in 1903, a decline in range forage and livestock production was apparent and the restoration of full productivity was considered a primary problem.

Twelve years later, in 1915, the major objectives for the work on the Santa Rita were listed as: (1) obtaining and maintaining maximum range productivity, and (2) increasing livestock income without damaging the range.

Here, again, a recognized decline in range productivity is implied and the maintenance of a high level of range productivity is given top priority. However, the importance of good range livestock husbandry was considered a close second in importance. In the years that followed, more progress was made in working out good range animal husbandry practices

than in solving the riddle of declining range productivity. Consequently, in Parker's analysis of range problems of the Southwest in 1948, "deterioration in grazing capacity since the introduction of domestic livestock" was listed again as the number one range problem. Other major range problems listed by Parker were: (2) drought in relation to herd make-up, supplementing, and grazing management, (3) improper distribution of livestock, (4) invasion of low value native woody plants, (5) improving the range by adjustment in numbers, reseeding, and water spreading, (6) control of rabbits and rodents, and (7) a better understanding of the effect of fertility on range forage production.

For the Santa Rita Experimental Range, Parker suggested a research program to determine the effects of: (1) eliminating woody plants on forage production and soil movement, (2) yearlong vs. seasonal grazing, (3) heavy yearlong vs. moderate yearlong grazing, and (4) how to restore deteriorated sites by artificial reseeding. All four of these phases of research activity would be directed to the overall problem of restoring and maintaining range productivity.

The most recent evaluation of range problems on the Santa Rita was made by Pearse in 1953. He listed the major considerations as: (1) the serious nature of drought and its impact on vegetation and grazing use, (2) the overwhelming increase of shrubs and the resultant loss in grazing capacity, and (3) the prevalent decline in range condition and grazing capacity, above and beyond that due to drought or shrub invasion, on the ranges that have been grazed on a yearlong basis.

Thus, Pearse, too, recognized the seriousness of decreased grazing capacity and attributed the decline to: (1) drought, (2) competition from

woody plants, and (3) improper grazing. He proposed a research program that would compare (1) flexible vs. constant conservative stocking as a means of minimizing the harmful effects of drought, (2) seasonal vs. yearlong grazing as a means of maintaining range productivity, and (3) the returns from grassland vs. shrub rangelands as a means of determining the economic feasibility of controlling woody plants on semidesert rangelands.

This brief look at the record indicates that the major range problem in the Southwest, that of maintaining and improving forage production, has been only partially solved by over 50 years of research. Even so, progress has been made toward a solution. Some of the things we know now that we did not know in 1903 are: (1) that mesquite, burroweed, and other nonforage plants are partially responsible for the declines in forage production and grazing capacity on the Santa Rita, (2) that droughts can be and often are severe enough to reduce stands of forage plants even under the best of grazing management or under total protection from livestock grazing, and (3) the consistent decline in range productivity throughout the Santa Rita under yearlong grazing raises a question as to the practical possibility of maintaining an adequate forage stand under yearlong grazing.

PROPOSED STUDIES IN GRAZING MANAGEMENT

The Santa Rita Experimental Range provides an opportunity for applying a limited number of grazing practices on a pasture basis. These grazing practices can be evaluated in terms of their effects on the livestock and vegetation. Because of the limited amount of manpower available for grazing management research it is necessary that the grazing treatments be

set up to require a minimum of the researcher's time. To accomplish this, all pastures except those being used to test flexible stocking will be stocked at constant levels and seasons of use. This practice will do away with the need for making yearly forage production and utilization surveys for the purpose of adjusting stocking and will free research time for detailed studies of the impact of grazing treatment, plant control treatment, etc., on production, utilization, palatability, nutritive value and other important growth characteristics of forage species.

Although it is believed that the pasture arrangement will be suitable for the studies to be outlined, certain shortcomings should be recognized. The pastures are far from comparable in size, shape, vegetation, soil, and ownership (hence grade and management) of cattle using them. However, the main objective in these studies is to determine whether individual pastures improve or decline under the grazing treatments imposed. It is not assumed that the pastures are comparable at the beginning of the study nor will the final conditions of the pastures be compared directly. Instead, the variable to be used for comparing effects of grazing treatment will be the amount of change for better or worse that occurs in each during the treatment period. Also, since differences due to grazing treatments are expected to be large, the studies planned should give significant results.

The grazing studies planned are:

(a) A study of yearlong vs. seasonal grazing on mesquite infested ranges. This study will involve pastures 3, 5, 6B, 12B, and the north half of pasture 2 (Appendix I).

(b) A comparison between cleared and mesquite infested foothill ranges. This study will involve pastures 1, 7, 8, and 10 (Appendix II).

(c) A test of flexible stocking based on total production of all classes of forage. This study will be made in a single pasture to determine something of the range of differences in forage production and stocking rates that may be expected from year to year. Stocking to be based on 50 percent utilization of all forage. This test will be run in pasture 12A (Appendix III).

(d) A study of the use of water, salt, and/or mineral and protein supplements to control the distribution of grazing use. One poorly watered pasture, 15, and a well watered pasture, 6A, will be used in this test. Stocking in these pastures will be on a yearlong basis with only such fluctuations as are needed to give proper flexibility to pasture 7 (Appendix IV).

(e) Plans for pastures not included in specific grazing studies. Pastures 4, 9, the south half of 2, and all traps may be used for plot work of various kinds. These pastures are also to be used to provide the necessary flexibility for adjusting cattle numbers to the forage supply in pastures where flexible stocking is specified. Stocking will be variable up to a fixed maximum number for each pasture. Adjustment of cattle numbers below the maximum will be at the discretion of the cooperating stockman.

SUMMARY

Foremost among problems confronting ranchers on southwestern semidesert ranges are those of learning to cope with drought, controlling unwanted plants, and learning to graze the range without damaging it permanently. Consequently, it is desirable to provide opportunities for studying interactions between grazing, drought, and plant control. The proposed grazing plan for the Santa Rita will provide some of those opportunities. A major objective in getting the proposed grazing treatments under way promptly is to provide a variety of grazing conditions under which more detailed studies may be conducted.

LITERATURE CITED

(1) Anderson, Darwin, et al

1953. Reseeding desert grassland ranges in southern Arizona. Ariz. Agr. Exp. Sta. Bul. 249, 32 pp., illus.

(2) Barr, George W.

1948. Arizona Agriculture. Ariz. Agr. Exp. Sta. Bul. 211, pp. 1-18. Illus. With map of irrigated land.

(3) Campbell, R. S., and Bomberger, E. H.

1934. Occurrence on gutierrezia sarothrae on bouteloua eriopoda ranges in southern New Mexico. Ecol. 15: 49-61.

(4) Campbell, R. S., and Crafts, Edward C.

1939. How to keep and increase black grama on southwestern ranges. U. S. Dept. Agr. Leaflet 180, 8 pp.

(5) Canfield, Roy H.

1941. Application of the line interception method in sampling range vegetation. Jour. For. 39(4): 388-394.

(6) _____

1942. The relative grazing preference of cattle for common semidesert grasses in southern Arizona. Southwestern For. & Range Exp. Sta. Res. Note 102, proc.

(7) _____

1944. Measurement of grazing use by the line interception method. Jour. For. 42(3): 192-194. Illus.

(8) _____

1944. A short-cut method for checking degree of forage utilization. Jour. For. 42(4): _____.

(9) Canfield, Roy H.

1948. Perennial grass composition as an indicator of condition of southwestern mixed grass ranges. Ecol. 20(2): 190-204, Illus.

(10) Cassady, John T., and Glendening, Geo. E.

1940. Revegetating semidesert range lands in the southwest. CCC For. Publ. No. 8, 22 pp. Illus.

(11) Clements, F. E.

1920. Plant indicators. Carnegie Inst. Wash. Publ. 290.

(12) Culley, Matt J.

1937. How to get sustained forage production in grazing semidesert mixed grass ranges. West. Livestock Jour. 2 pp., illus. Apr.

(13) _____

1937. An economic study of cattle business on a southwestern semi-desert range. U. S. Dept. Agr. Circ. No. 448, 24 pp. Illus.

(14) _____

1938. Grazing habits of range cattle. American Cattle Producer, pp. 3,4, 16-17, Illus. Jan.

(15) _____

1939. Rodents or cattle? West. Livestock Jour. 2 pp. Illus, Mar.

(16) _____

1941. Does it rain less now than in the old days? West. Livestock Jour. 1 p. Illus. July.

(17) _____

1943. Proper stocking pays dividends. West. Livestock Jour. 1 p. Illus. Apr.

(18) _____

1943. Grass grows in summer or not at all. Hereford Jour. 1 p. Illus. Sept.

(19) Culley, Matt J.

1946. Factors affecting range calf crop. Ariz. Stockman, pp. 30-37, Illus. Nov.

(20) _____

1949. The Santa Rita Experimental Range. Southwestern For. & Range Exp. Sta. 10 pp. (proc.) Rev.

(21) Fisher, C. E.

1947. Present information on the mesquite problem. Texas Agr. Exp. Sta., A & M Coll. Tex. Prog. Report 1056, 7 pp. Illus. (proc.)

(22) Glendening, George E.

1952. Some quantitative data on the increase of mesquite and cactus on a desert grassland range in southern Arizona. Ecol. 33(3): 318-328, Illus.

(23) _____ and Paulsen, Harold A.

1955. Reproduction and establishment of velvet mesquite as related to invasion of semidesert grasslands. U. S. Dept. Agr. Tech. Bul. 1127, 50 pp. Illus.

(24) Humphrey, R. R.

1937. Ecology of the burroweed. Ecol. 18(1): 1-9, Illus.

(25) Knox, J. H., and Watkins, W. E.

1942. The use of phosphorus and calcium supplements for range livestock in New Mexico. New Mex. Agr. Exp. Sta. Bul. 287, 18 pp. Illus.

(26) Lantow, J. L.

1933. The assimilations of calcium and phosphorus from different mineral compounds and their effect on range cattle. New Mex. Agr. Exp. Sta. Bul. 214, 32 pp. Illus.

(27) Lister, P. B.

1939. Forage plant utilization varies by seasons on semidesert lands. Ariz. Stockman 5:10-11 [Also Swn. For. & Range Exp. Sta. Res. Note 40).

(27a) _____, and Schumacher, F. S.

1937. The influence of rainfall upon tuft area and height growth of three semidesert range grasses in southern Arizona. Jour. Agr. Res. 54(2): 109-121.

(28) Martin, S. Clark

1946. Bet on the rainfall and win. Ariz. Stockman 12(4): 10-13.

(29) _____

1949. Controlling mesquite with diesel oil. Swn. For. & Range Exp. Sta. Res. Note 115 (proc.).

(30) Parker, Kenneth W.

1939. The control of burroweed. Swn. For. & Range Exp. Sta. Res. Note 72, 4 pp. (proc.).

(31) _____

1940. Use of arsenic in the control of mesquite in the southwest. Swn. For. & Range Exp. Sta. Res. Note 88.

(32) _____

1943. Southwestern stockmen--play to win! U. S. Dept. Agr. AMI-74, 15 pp. Illus.

(33) _____

1943. Control of mesquite on southwestern ranges. U. S. Dept. Agr. Leaflet 234, 8 pp. Illus.

(34) _____

1944. Adjust range stocking for heavier animals. The Cattleman. 2 pp. Illus. Aug.

(35) _____

1948. An analysis of range problems in the southwest. In files, Rocky Mt. For. & Range Exp. Sta. 130 pp., typed.

(36) Parker, Kenneth W., and Martin, S. Clark

1952. The mesquite problem on southern Arizona ranges. U. S. Dept. Agr. Circ. 908, 70 pp., Illus.

(37) Pearse, C. Kenneth

1953. Problem analysis and working plan for grazing management research Santa Rita Experimental Range. In files, Rocky Mountain For. & Range Exp. Sta. 26 pp., typed.

(38) Reynolds, Hudson G.

1954. Meeting drought on southern arizona rangelands. Jour. Range Mangt. 7(1): 33-40.

(39) Roach, Mack E.

1950. Estimating perennial grass utilization on semidesert cattle ranges by percent of ungrazed plants. Jour. Range Mangt. 3: 182-185.

(40) Shantz, H. L., and Zon, Raphael

1924. Atlas of american agriculture. Part I. The physical basis of agriculture. Section E, natural vegetation. U. S. Dept. Agr. Bur. Agr. Econ. Publ. 24 pp., Illus.

(41) Shreve, Forrest

1917. A map of the vegetation of the United States. The Geographical Rev. Vol. III, pp. 119-125.

(42) _____

1937. Thirty years of change in desert vegetation. Ecol. 18(4): 463-478.

(43) Stanley, E. B., and Hodgson, C. W.

1938. Seasonal changes in the chemical composition of some Arizona range grasses. Ariz. Agr. Exp. Sta. Tech. Bul. 73, pp. 451-466.

(44) Talbot, M. W.

1937. Indicators of southwestern range condition. U. S. Dept. Agr. Farmers' Bul. 1782, 35 pp. Illus.

(45) U. S. Dept. Agriculture

1925. Santa Rita Range Reserve. Forest Service, 20 pp. (proc.).

(46) _____

1943. Market your range cattle in the best condition. AWI-55, 9 pp. Illus.

(47) Watkins, W. E.

1943. Composition of range grasses and browse at varying stages of maturity. New Mex. Agr. Exp. Sta. Bul. 311. 43 pp. Illus.

APPENDIX I

TENTATIVE OUTLINE

A STUDY OF YEARLONG VERSUS SEASONAL GRAZING ON
LOW-VALUE MESQUITE INFESTED RANGES

(Pastures 3, 5, 6B, 12B, and N½ of 2)
(See Fig. 2)

Objectives:

1. To determine whether growing season, dormant season, or yearlong grazing use is best for low-value grass-shrub range.

2. To determine whether cattle do better on such ranges if shifted from one area to another twice annually or if yearlong use is preferable.

Seasons of Use:

Growing Season--(6/1-11/15) to be applied to pasture 12B and the south half of pasture 5.

Dormant Season--(11/16-5/31) to be applied to pasture 3 and the north half of pasture 5.

Yearlong--to be used in pasture 6B and in the north half of pasture 2.

Rate of Stocking:

The maximum stocking rate will be the average stocking rate for the past 10 years. In times of feed shortage the cooperator will be permitted to reduce numbers to what he considers a safe level.

Duration of Test:

10 years, with possible extension if results warrant.

Records to be Taken:

A. Vegetation

1. Basal density and species composition of perennial grasses.

2. Annual utilization estimate.

3. Annual forage yield estimate.

4. Repeat photographs as needed.

B. Livestock

1. Calf crops, death losses, actual use records, etc., as now kept and as much data as is practical on weights of cows, calves, etc.

2. In order to determine possible cumulative effects on livestock, it would be most desirable to keep the same basic herd of cattle in each pasture, or pair of pastures, throughout the study period.

Improvements Necessary:

A. Fencing

1. 4¼ miles of fence to divide pasture 5 into 2 parts.

2. 3¼ miles of fence to divide pasture 2 into 2 parts.

B. Water developments

1. New rim at Desert Corral

2. New rim at Box R.

3. Arrange fences so that NW Rim and N. Rim may be opened to either side of the division fence in pasture 5.

Schedule:

CY 1956

1. Prepare detailed study plan.

2. Construct fences and water developments.

CY 1957

3. Set up sampling sites and take initial records.

4. Begin winter grazing in 12B and S½ of 5 on November 16.

APPENDIX II

TENTATIVE OUTLINE

A COMPARISON BETWEEN CLEARED AND MESQUITE INFESTED FOOTHILL RANGES

(Pastures 1, 7, 8, & 10)
(See Fig. 2)

Objectives:

1. To determine the relative carrying capacities of cleared and uncleared foothill range when stocked on a yearlong basis.

2. To determine the magnitude of year-to-year fluctuations in the amount of perennial grass produced and of consequent adjustments in cattle numbers.

3. To determine trends in vegetation changes on cleared and uncleared range when yearlong flexible stocking is used.

Season of Use:

Yearlong.

Rate of Stocking:

Stocking will be adjusted annually in the fall. Basis for stocking will be 40 percent of the current year's growth of perennial grass herbage.

Length of Study:

The current study will run for 10 years with possible extension at the end of the period.

Records to be Taken:

A. Vegetation

1. Basal density and species composition of perennial grasses.

2. Annual forage yield estimate.

3. Annual utilization estimate.

4. Range condition rating by 3-step method to be made at each permanent transect location in 1956, 1959, and 1961.

5. Number of mesquite on belt transects at permanent line transect locations will be used to determine rate of reinvasion by mesquite.

6. Photographs as needed.

B. Livestock

1. Actual use, death losses, calf crops, etc., as now kept and as much data as is practical on weights of cows, calves, etc.

2. In order to determine possible cumulative effects on livestock, it would be most desirable to keep the same basic herd, or their descendents in each pasture throughout the study period. In-and-out cattle needed to adjust cattle numbers to forage yields could come from another source.

Improvements Necessary:

No physical improvements are necessary to conduct this study except that the clearing of mesquite from pastures 1 and 7 is to be completed and necessary follow-up provided. However, facilities for weighing the cattle from individual pastures would be very desirable.

Schedule:

C.Y. 1956

1. Prepare detailed study plan.

2. Complete mesquite clearing in pastures 1 and 7.

3. Complete establishment of permanent line transects and other sampling points.

4. Take initial range condition data and photographs.

5. Take forage yield data and adjust stocking to indicated rate.

APPENDIX III

TENTATIVE OUTLINE

A TEST OF FLEXIBLE STOCKING BASED ON TOTAL PRODUCTION OF ALL CLASSES OF FORAGE
(Pasture 12A)
(See Fig. 2)

Objectives:

1. To determine the magnitude of year-to-year changes in forage production and rate of stocking if all classes of forage are given equal weight.

2. To determine whether range condition improves or deteriorates under the system.

3. To determine any desirable or undesirable effects of this kind of grazing on livestock.

Seasons of Use:

Yearlong

Rate of Stocking:

Stocking will be adjusted annually around November 1. Stocking will be calculated to use 40 percent of the combined production of annual grasses, perennial grasses, and browse.

Duration of Test:

Ten years, with extension if results warrant.

Records to be Taken:

A. Vegetation

1. Basal density and species composition of perennial grasses.

2. Annual forage yield estimate.

3. Annual utilization estimate.

4. Range condition rating by 3-step method to be made at each permanent transect location in 1956, 1959, and 1961.

5. Photographs as needed.

B. Livestock

1. Actual use, death losses, calf crops, etc., as now kept.

2. Calf weight at shipping time.

3. Weight of all cattle approximately November 1 and June 1.

Improvement Necessary:

None

Schedule:

C.Y. 1956

1. Prepare detailed study plan.

2. Complete establishment of permanent transects and take initial records.

C.Y. 1957

3. Take initial range condition data and photographs.

4. Take forage yield data and adjust stocking to indicated rate.

5. Weigh cattle into pasture.

Though limited in value because of lack of replication, any striking effects produced by the treatment in pasture 12A can be compared with those obtained by various types of seasonal grazing in the study involving pastures 2N, 3, 5, 6B, and 12B, and with yearlong constant stocking in pasture 4.

APPENDIX IV

TENTATIVE OUTLINE

A STUDY OF THE USE OF WATER, SALT, AND/OR MINERAL AND PROTEIN SUPPLEMENTS TO CONTROL DISTRIBUTION OF GRAZING USE

(Pastures 6A and 15)
(See Fig. 2)

Objectives:

1. To determine to what extent the use of salt, and/or salt supplement mixes can be used to obtain more uniform grazing use on a poorly watered range.

2. To determine to what extent the control of stock water and the placement of supplements can be used to provide the benefits of deferred and rotational grazing within a single large pasture.

Season of Use:

The pasture as a whole will be grazed yearlong but use of certain areas in pasture 6A will be deferred by closing up the water.

Rate of Stocking:

Stocking will be essentially constant at about the average for the 1946-55 period. However, pastures 15 and 6A will be used to provide the flexibility needed to operate pasture 7 on a year-to-year flexible basis.

Length of Study:

About 10 years, longer if necessary.

Records to be Taken:

A. Vegetation

1. To be worked out.

B. Livestock

1. Actual use, death losses, calf crops, etc., as now taken.

2. Fall calf weights (Pasture 6A, only).

3. Fall and spring weights of cows (Pasture 6A, only).

Improvements Necessary:

None

Schedule:

C.Y. 1956

1. Continue studies already underway in pasture 15.

C.Y. 1957

2. Make detailed plan for study in 6A.

Additional comparisons which may be possible in connection with pasture 6A should be used to determine benefits to the range from closing permanent water at times when temporary water is available. Possible comparisons include:

1. Water at Huerfano Rim to be open yearlong in pasture 6B but to be closed during growing season across the fence in pasture 6A.
2. Box Rim area in pasture 2N to be compared with Box Rim area in pasture 6A.
3. A type of season-of-use study within the pasture can be made by comparing summer-fall grazed areas around the Red tank and East tank with winter-spring grazed areas at Huerfano Rim and East Rim.
4. Still another comparison will be that between pasture 15, a poorly watered pasture, with pasture 6A which has excellent water distribution.

APPENDIX V

TENTATIVE PLANS FOR PASTURES
NOT INCLUDED IN SPECIFIC GRAZING STUDIES

(Pastures 4, 9, the south half of 2 and all traps)
(See Fig. 2)

Pasture 4

Pasture 4 is to be cleared of mesquite as funds are available. Consequently it will be undergoing some change and is not suitable for use in a grazing study at this time. It will be stocked at not to exceed 20 animal units yearlong for the next 5 years. This pasture may be used by the cooperator to provide some of the flexibility needed in pastures 1 and 8.

Pasture 9

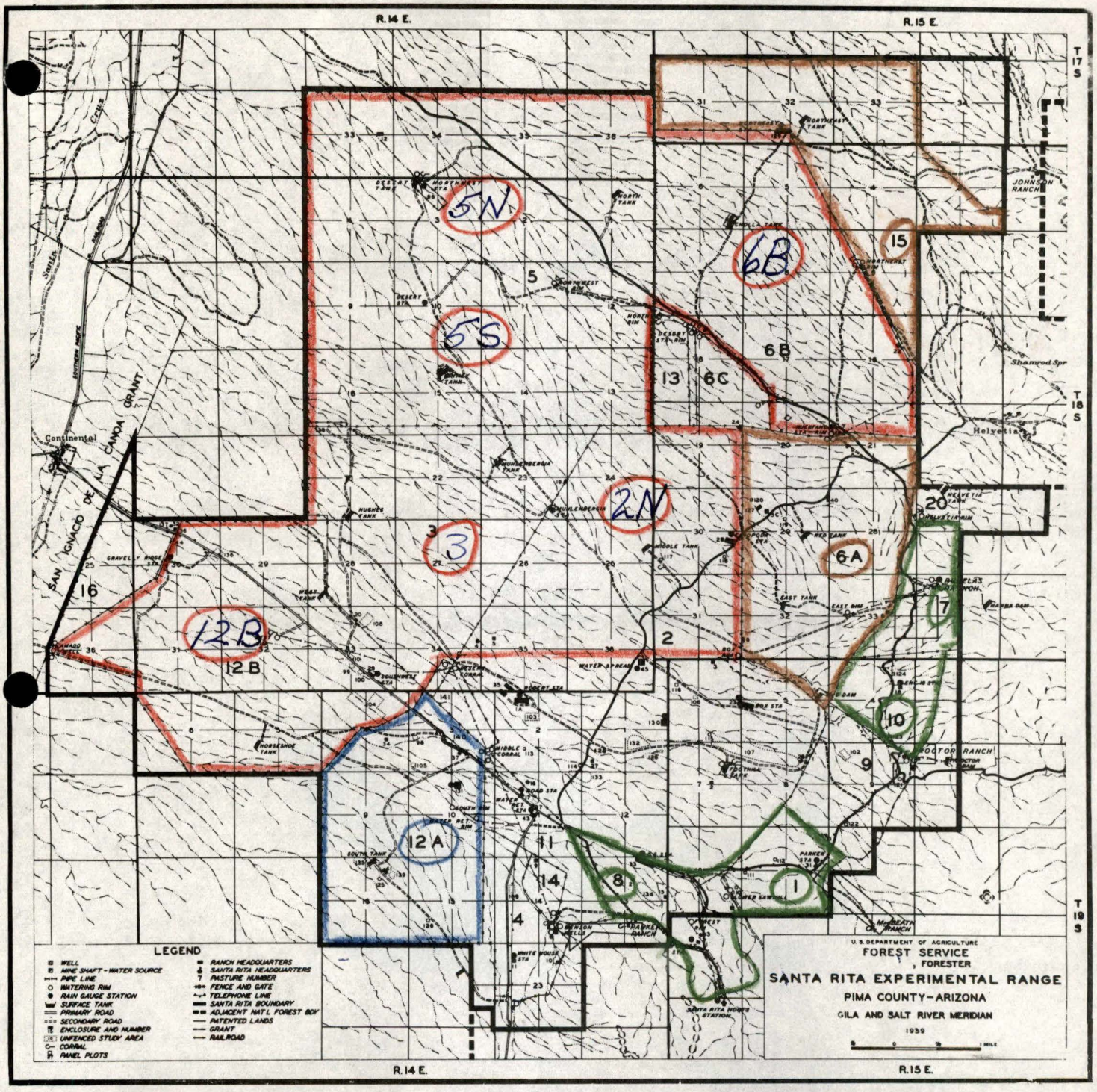
Pasture 9 is also to be cleared of mesquite as time and funds permit. It may also be used in a variety of plot studies or plant control. During the next 5 years, pasture 9 will be stocked at not more than 25 animal units yearlong. Pasture 9 may be used by the cooperator to provide the necessary flexibility of cattle numbers in pasture 10.

South Half of Pasture 2

Pasture 2, south half, will be the center of mesquite control tests of various types by A.R.S. It will be stocked for the next 5 years at not to exceed 65 animal units yearlong. It will also be used by the cooperator to provide the flexibility needed in the plans for pasture 12A and to some extent pastures 1 and 8.

Traps

All traps such as pastures 6C, 11, 11A, 13, 14, 16, 20, 140, and 141 will be used about as they are now as holding traps. They are essential to the overall management of the Experimental Range and cattle, but their use is too erratic to permit the establishment of formal grazing studies in them.



Notes

	Portion of Range involved in seasonal grazing study	(Appendix I)
	" " "	cleared vs. mesquite range (Appendix II)
	" " "	all forage study (Appendix III)
	" " "	use distribution study (Appendix IV)
	" "	not assigned to specific studies.

Figure 2.--Map of Santa Rita Experimental Range showing assignment of pastures to grazing studies.